Early Career: **Development of Lightweight, Radiation- and Damage-Tolerant Micro-trusses**

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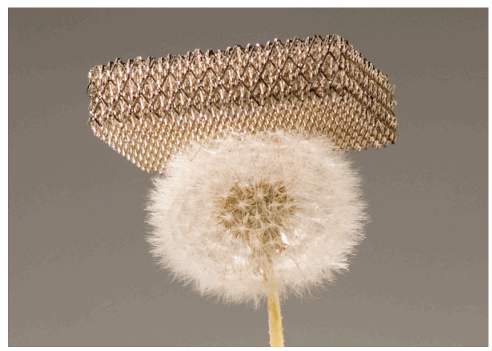
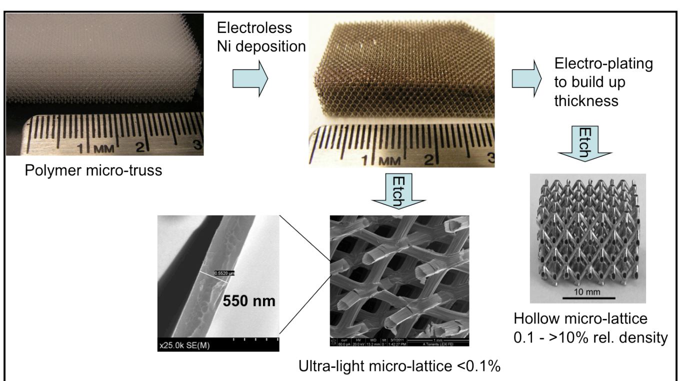
Motivation. NASA report titled "DRAFT Materials, Structures, Mechanical Systems, and Manufacturing Roadmap" provides a summary of the MSMM top 10 technical challenges that are critical to NASA's mission, among which – at the very top – are Radiation Protection (Top Challenge), Advanced Materials, and Lightweight Structures.

Utilizing architectural features as key elements in defining multi-dimensional material design space promises to enable independent manipulation of the currently coupled physical attributes and to develop materials with unprecedented capabilities. Using architectural features to elicit desired functionality will shift the material creation paradigm from structure→processing→property to property→architecture→fabrication. Feasibility of this "reverse" material construction approach, is gated by our ability *to understand* and *predict* mechanical response of these "metamaterials" (materials whose properties are controlled by their engineered structure rather than by atomic composition alone), where a new design parameter, feature **size**, plays a critical role.

Project Objectives. The proposed work seeks to design and create metallic nanolaminates with optimized nano-scale thicknesses architected into 3-dimensional periodic hollow micro-truss geometries. It has been found that interfaces, i.e. boundaries between dissimilar materials or atomic structures, can serve as effective sinks for radiation-induced defects. Hence, composites with a large relative fraction of interfaces (i.e. nanolaminates) promise to provide an over an order of magnitude increase in radiation damage tolerance – mainly due to the unique dislocation interactions and free volume absorption within these interfaces. Hollow metallic micro-trusses developed in collaboration with Hughes Research Lab colleagues (see below) by PI's group have recently attracted much interest as they attained GPa-level stiffnesses at ~10% of the density of the parent solid (see Figure on the right). The main thrust and the novelty of the proposed work lies in utilizing controlled microstructural architecture to combine the micro-truss geometries, which offer extremely light weight and lend themselves to coating with a wide range of metals/metallic systems, with nanometer-sized (both crystalline and amorphous) metallic nanolaminates, which offer enhanced radiation tolerance. Such an out-of-the-box approach to material synthesis promises to harness the beneficial properties offered by nano materials and proliferate them onto larger scales. This, in turn, will enable combining the extremely light weight, radiation immunity, and enhanced stiffness and toughness in a single material. These nanolaminate micro-trusses promise to provide a powerful property control platform for NASA missions as they will serve as enablers of radiation-tolerant paneling and shielding, small-scale spacecrafts and/or deployable structures capable of landing on the Moon, asteroids, as well as explore deep space.





Electro-deposition enables conformal coatings with controlled thickness from nm to mm

The PI will collaborate with Dr. Doug Hofmann and Dr. Frank Greer (JPL) and will continue to collaborate with Dr. Bill Carter, Dr. Alan Jacobsen, and Dr. Tobias Schaedler (Hughes Research Laboratory).